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A Photographic Catalog of Killer Whales, *Orcinus orca*, from the Central Gulf of Alaska to the Southeastern Bering Sea

Marilyn E. Dahlheim

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The *NOAA Technical Report NMFS* (ISSN 0892-8908) series is published by the Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115-0070.

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On the cover
Illustration of killer whales, *Orcinus orca*, by Katherine Zecca.

Suggested reference
M. E. Dahlheim. 1997. A photographic catalog of killer whales, *Orcinus orca*, from the central Gulf of Alaska to the southeastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 130, 58 p.

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A Photographic Catalog of Killer Whales, *Orcinus orca*, from the Central Gulf of Alaska to the Southeastern Bering Sea

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ABSTRACT

In 1992 and 1993, researchers from the National Marine Mammal Laboratory initiated photo-identification studies on Alaskan killer whales, *Orcinus orca*. Waters from Kodiak Island west to the central and eastern Aleutian Islands and southeastern Bering Sea were surveyed. A total of 289 individual whales were identified. A photographic record of the whales encountered during these surveys is presented. When photographs of the 289 individual whales were compared among various regions in Alaska (Prince William Sound and Southeast Alaska) and areas outside Alaska (British Columbia, Washington, and California), 11 matches were found. The count is conservative because the 1992 and 1993 surveys were limited in geographical range, restricted to summer periods, and whales may have been missed along the survey trackline. Future research incorporating both photo-identification studies and line transect surveys will provide reliable abundance estimates of Alaskan killer whales.

Introduction

There are few systematic survey data to estimate population abundance of killer whales (*Orcinus orca*) in Alaska. The National Marine Mammal Laboratory's (NMML) Platforms of Opportunity Program provides a 34-year record (1957–1991) of killer whale sightings throughout Alaska (Fig. 1). Although these data are valuable with respect to overall distribution of killer whales (Braham and Dahlheim, 1982), sightings were collected opportunistically and a dedicated search effort has been lacking. As a result, the sighting data are not useful for estimating population abundance or trends.

Leatherwood et al. (1983) report the results of eight aerial surveys conducted off Kodiak Island, from Unimak Pass westward along the Aleutian Islands, and between Unalaska Island and the Pribilof Islands. A total of 36 killer whale groups, totaling 236 individuals, were sighted. Abundance was not estimated because repeat sightings of the same pod(s) could not be distinguished from single sightings. Brueggeman (1987) flew 38,000 nautical miles (n mi) of aerial surveys from April to December 1985 in the Shumagin Islands, the North Aleutian Basin, and St. George Basin. A total of 25 groups (67 killer whales) were observed. Duplicate sightings were not considered, thus the actual number of killer whales seen was probably less.

Beginning in 1972, killer whale population biology was studied through the use of photo-identification techniques. This method was pioneered by Bigg and Balcomb when they showed that a combination of dorsal fin shape, nicks in the dorsal fin, shape of the saddle patch, and scars on the dorsal surface of the animal were specific to individual killer whales (Balcomb and Bigg, 1986; Bigg et al., 1987; Bigg et al., 1990). Thus, individual killer whales could be tracked both temporally and spatially through the collection of photographs (Olesiuk et al., 1990).

In the late 1970's, researchers in Alaska began collecting identification photographs of Prince William Sound killer whales (Hall, 1981). In 1984, Prince William Sound whales were first assigned to pods based on observed associations of individuals (Leatherwood et al., 1984). This resulted in the production of the first catalog of Prince William Sound killer whales (Ellis, 1984); the catalog was updated in 1987 (Ellis, 1987) and again in 1991 (Heise et al., 1991). In 1984, photographic studies on killer whales were also initiated in

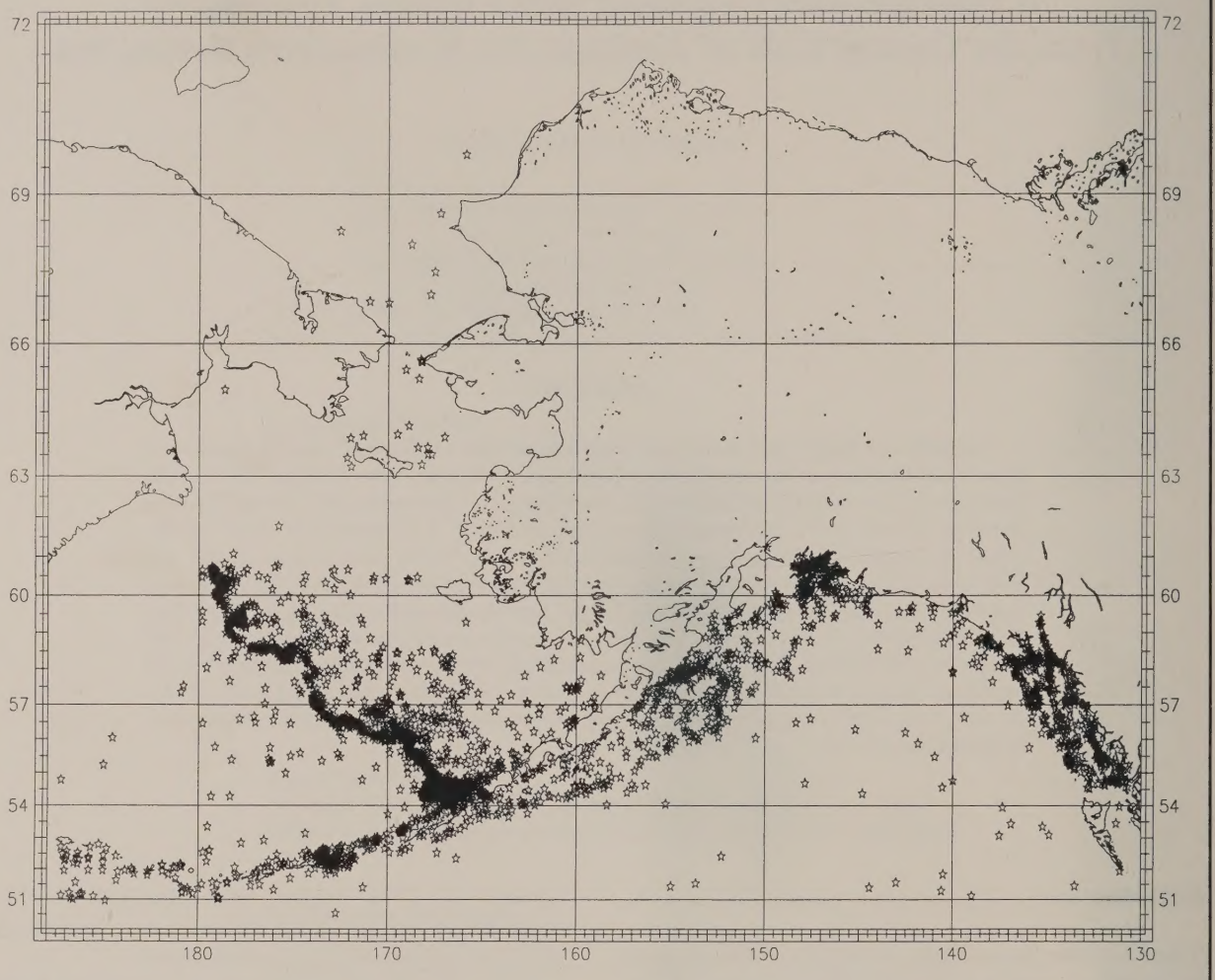


Figure 1
Sightings of Alaskan killer whales from the National Marine Mammal Laboratory's Platform of Opportunity Program, 1957–91.

Southeast Alaska (Leatherwood et al., 1984) with photographs of individual killer whales from Southeast Alaska included in Ellis (1984, 1987). Although opportunistic photographs of killer whales were collected between the years 1985 through 1988 (Prince William Sound and Southeast Alaska), photo-identification research was limited in both areas. Between 1989 and 1997, researchers from the NMML carried out dedicated photo-identification research on killer whales throughout Alaskan waters. Although certain geographical regions were studied each year (e.g. Southeast Alaska), research in other regions was sporadic.

In 1992 and 1993, NMML initiated photo-identification studies on killer whales that occur from the central Gulf of Alaska west to the southeastern Bering Sea and eastern and central Aleutian Islands region (Fig. 2). The objectives of this particular study were to:

1. Develop a photographic identification catalog of all killer whales encountered.
2. Obtain a minimum count of killer whales in the southeastern Bering Sea, eastern/central Aleutian Islands region, and the western and central Gulf of Alaska.
3. Establish baseline data for designing protocol for estimating population abundance of killer whales in Alaska.
4. Develop a baseline of information for long-term studies of killer whales in Alaska.

This document provides a photographic record of each killer whale encountered during the 1992 and 1993 NMML investigations observed from the Central

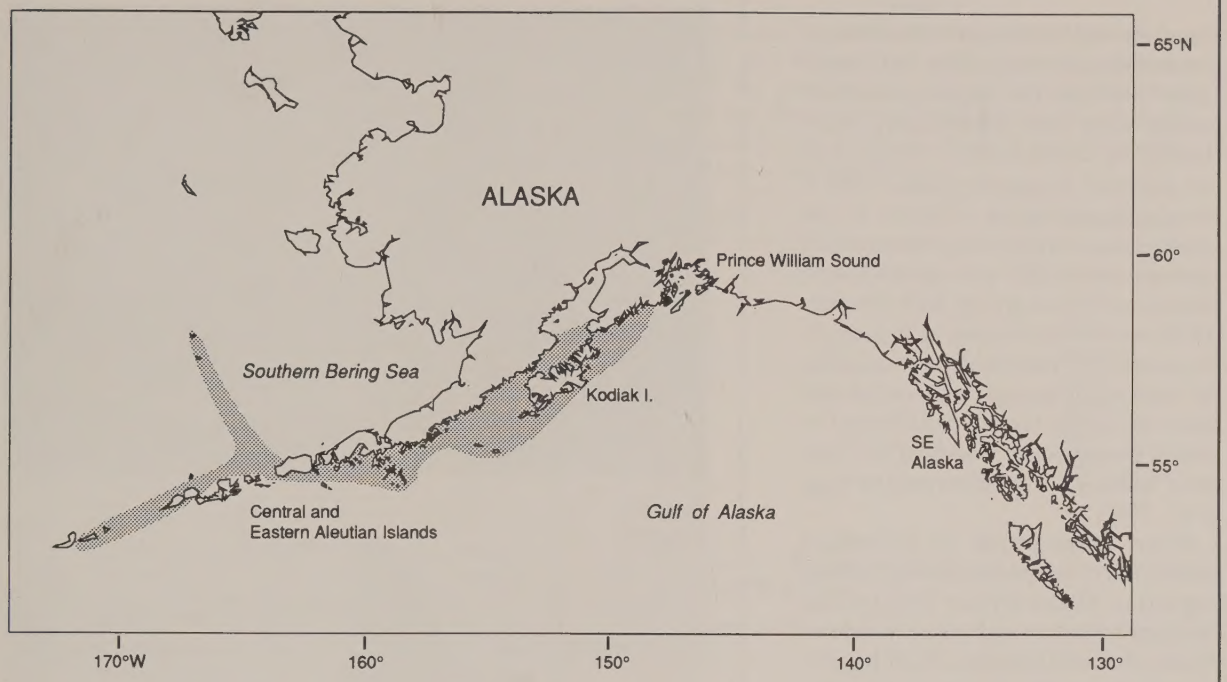


Figure 2
Areas surveyed during 1992/1993 killer whale NMML investigations.

Gulf of Alaska west to the eastern/central Aleutian Islands and southeastern Bering Sea. It is not the intent of this document to report on the details of the scientific results of the Kodiak Island/Bering Sea study or present the photographic record of whales encountered in other Alaskan regions. These data are pending publication in separate documents.

Methods

When killer whales were encountered, two skiffs were launched (weather permitting) from the support vessel to obtain photographs of individual whales. Researchers aboard the skiff selected a course and speed to approximate that of the whales' to facilitate optimal photographic positioning. An approach within 20–30 m was required to obtain a high-quality photograph. Photographs were taken of the left side of the killer whale's dorsal fin and saddle patch. A Nikon 8008 (35 mm SLR) auto-focus camera was used. The camera was equipped with a motor drive and a 300 mm lens. The camera shutter speed was set to 1/2000th second. The film type selected allowed for a high shutter speed and good depth of field (e.g. black and white Fuji 1600).

Photographs were analyzed for individual killer whale identification. Obvious nicks or scarring on the saddle patch were noted (Fig. 3). Sub-standard photographs (i.e. not showing enough detail or improper angle/side) were discarded, thus reducing the probability of mis-identification or mis-matching photographs. Two independent readers reviewed the photographs to obtain the total number of individual whales. If independent readers disagreed with a particular identification (which was not the case in this study), another independent reader was asked to review the photograph in question. The minimum count was obtained by listing the number of individual whales photographed. Photographs of each whale identified during this study were then compared to the killer whale photographic database available from other regions (e.g. Prince William Sound [Heise et al., 1991; NMML[1]], Southeast Alaska [Dahlheim et al., 1997], British Columbia and Washington State [Bigg et al., 1987; Ford et al., 1994], and California [Black et al., In press]).

[1] National Marine Mammal Laboratory, Seattle, WA, unpublished data.

Results and Discussion

Based on the 1992 and 1993 surveys, 289 individual killer whales were identified.[2] Because the majority of whale groups were only encountered once during the 2-year survey, whales were not assigned to specific pods. Table 1 lists the identification numbers of the whale groups encountered during field operations (i.e. AK1 through AK4 were encountered as a group, AK5 through AK85 were encountered as a group). Because of the paucity of data available for each whale group (i.e. most whales seen only once), we did not attempt to classify the whales as "transient" or "resident" killer whales as described by Bigg et al., 1987.

When photographs of individual whales were compared among various regions in Alaska (Prince William and Southeast Alaska) and areas outside of Alaska (British Columbia, Washington, and California), 11 matches were found. Matches occurred between whales observed near Seward, Alaska (this study), and whales observed in Prince William Sound (Table 2). This is not surprising given that these two areas are only 35 n mi apart.

Despite considerable coverage during our investigations (i.e. approximately 5,000 n mi surveyed each year), few killer whales were encountered (289 individual whales documented). We suspect that the count is conservative because: 1) surveys were limited in geographical range, 2) surveys were restricted to the summer season, and 3) whales could have been present but missed along the survey trackline. However, the overall survey results obtained during the 1992 and 1993 investigations (i.e. relatively few whale groups encountered) are similar to those obtained by other investigators working in Alaska (Leatherwood et al., 1983; Brueggeman, 1987). Overestimation of killer whale abundance in the absence of systematic surveys may easily result because the same animals are repeatedly sighted at slightly different times or in different locations.

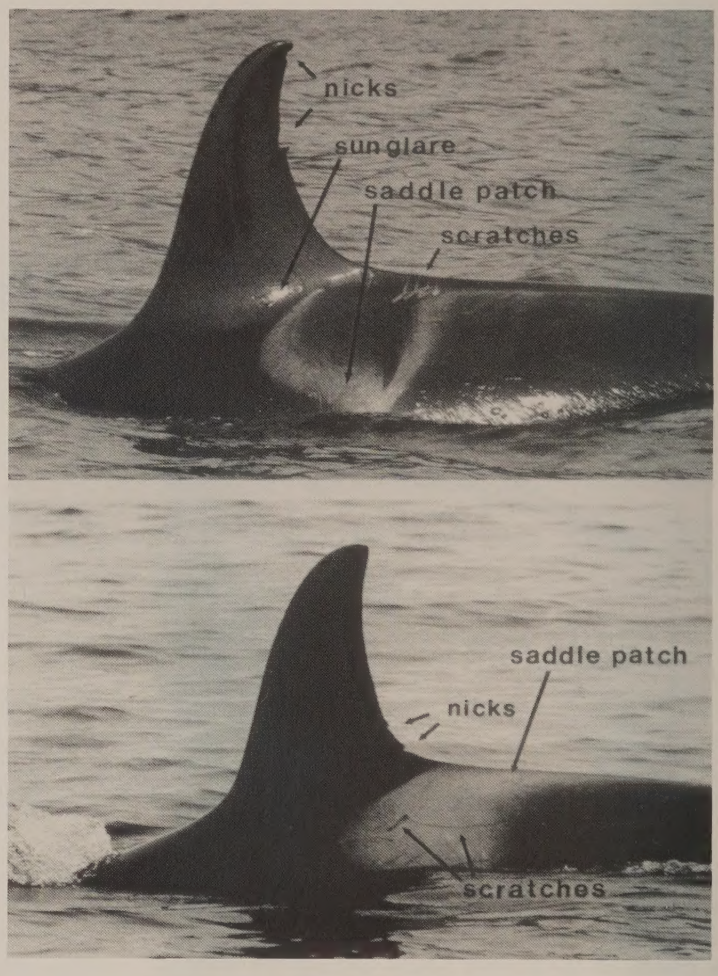


Figure 3
Various characters (e.g. nicks, saddle patch, scratches, etc.) used to identify individual killer whales.

Acknowledgments

Surveys of this magnitude could not have been completed without the help of many people. I thank our survey crews and photographers for their many hours of effort: K. Balcomb-Bartok, T. Chandler, B. Caruso, K. Chumbley, D. Ellifrit, J. Evenson, C. Hutchinson, J. Jacobsen, J. Lerczak, B. Mathews, B. Miller, R. Osborne, R. Ream, T. Schall, J. Sease, F. Sharpe, J. Stern, M. Strick, J. Swenson, R. Towell, and J. Waite. My appreciation is extended to the captain (Jon Williams) and crew of the *F/V Brielyn Marie*, and the captain (Tom Crawford) and crew of the *R/V Glorita*. Panda Laboratories (Dana Drake) developed all film related to this project and produced the high quality 5 × 7 prints used in this

[2] A match was found between AK173 and AK207 reducing the total number of whales from 290 to 289.

Table 1

Encounters with killer whales, *Orcinus orca*, off Kodiak Island, south side of the Alaska Peninsula, eastern and central Aleutian Islands, and the southeastern Bering Sea.

Date	Location	AK Number
1992		
7/12	Shelikof Strait	1–4
7/16	Chiswell Islands	5–85
7/17	Chiswell Islands	86–87
7/19	Portlock Banks	88–91
7/29	Shelikof Strait	92–95
8/4	Alaskan Peninsula	96–102
8/7	Unimak Pass	103–139
8/13	Amukta Pass	140–146
8/17	Bering Shelf	147–159
8/22	Unalaska Island	160–163
8/22	Unalaska Island	164–169
8/22	Unalaska Island	170–182
1993		
7/19	Albatross Banks	183–197
7/24	Pye Islands	198–200
8/16	Akutan Island	201–208
8/20	Bering Shelf	209–242
8/21	Unalaska Island	243–285
8/23	Bogoslof Island	286–290

Table 2

Photographic matches made of individual killer whales, *Orcinus orca*, between this study and Prince William Sound. No photographic matches were found when comparing whales observed during this study and whales photographed in Southeast Alaska, British Columbia, Washington, and California.

This study	Prince William Sound[1]
AK 34	AD 8
AK 36	AD 5
AK 37	AD21
AK 38	AD 4
AK 41	AD 2
AK 45	AD11
AK 48	AX19
AK 50	AX 8
AK 52	AX 1
AK 67	AX 6
AK 87	AT30

[1] See Heise et al., 1991.

catalog. Dave Ellifrit and Janice Waite conducted the analyses of the photographic data. Chris Boucher provided Figure 1. Bonnie Storm assisted in catalogue layout. The cover of this report was illustrated by Katherine Zecca (Graphics Unit, AFSC/NMFS). Howard Braham and Doug DeMaster provided valuable reviews of this report.

Literature Cited

Balcomb, K. C., and M. A. Bigg.
1986. Population biology of the three resident killer whale pods in Puget Sound and off southern Vancouver Island. *In* B. C. Kirkevold and J. S. Lockard (eds.), Behavioral biology of killer whales, p. 85–95. Zoo Biology Monographs, Vol. 1. Alan R. Liss, Inc., New York, N.Y.

Bigg, M. A., G. M. Ellis, J. K. B. Ford, and K. C. Balcomb.
1987. Killer whales: a study of their identification, genealogy and natural history in British Columbia and Washington State. Phantom Press and Publishers, Inc., Nanaimo, B. C., Canada, 79 p.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb.
1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. *In* P. S. Hammond, S. A. Mizroch, and G. P. Donovan (eds.), Individual recognition of cetaceans: use of photo-identification and other techniques to estimate population parameters, p. 386–406. Rep. Int. Whal. Comm., Special Issue 12.

Black, N. A., A. Shulman-Janiger, R. L. Ternullo, and M. Guerro-Ruiz.
In press. Killer whales of California and western Mexico: a catalog of photo-identified individuals. NOAA Tech. Memo. NMFS-F/SWFSC.

Braham, H. W., and M. E. Dahlheim.
1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643–646.

Brueggeman, J.
1987. Aerial surveys of endangered cetaceans and other marine mammals in the northwestern Gulf of Alaska and southeastern Bering Sea. Rep. to MMS and NOAA; OCSEAP Research Unit 673, Contract No. 85-ABC-00093, p. 4–73 to 4–83.

Dahlheim, M. E., D. K. Ellifrit, and J. D. Swenson.
1997. Killer whales of southeast Alaska: a catalogue of photo-identified individuals. Day Moon Press, Seattle, 79 p.

Ellis, G. M.
1984. Killer whales of Southern Alaska, a catalogue of individuals photo-identified in 1984. Hubbs Sea World Research Institute Tech. Rep. 84–176, 73 p.
1987. Killer whales of Prince William Sound and Southeast Alaska: a catalogue of individuals photo-identified, 1976–1986. Hubbs Sea World Research Institute Tech. Rep. 87-200, 76 p.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb.
1994. Killer whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington State. UBC Press (Vancouver, B.C., Can.) and University of Washington Press (Seattle), 102 p.

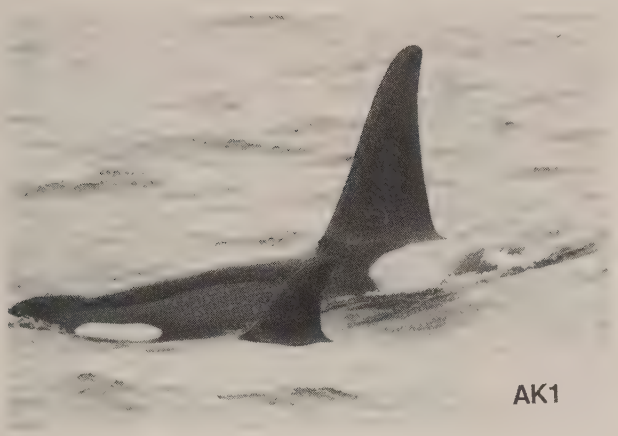
Hall, J. D.
1981. Aspects of the natural history of cetaceans of Prince William Sound, Alaska. Ph.D. dissert., University of California Santa Cruz, 101 p.

Heise, K., G. Ellis, and C. Matkin.
1991. A catalogue of Prince William Sound killer whales. North Gulf Oceanic Society, Homer, Alaska, 51 p.

Leatherwood, S., A. Bowles, and R. Reeves.
1983. Endangered whales of the eastern Bering Sea and Shelikof Strait, Alaska; results of aerial surveys, April 1982 through April 1983 with notes on other marine mammal behavior. Hubbs Sea World Research Institute Tech. Rep. 83-159:173–182.

Leatherwood, S., K. C. Balcomb III, C. O. Matkin, and G. Ellis.
1984. Killer whales (*Orcinus orca*) in southern Alaska. Hubbs Seaworld Research Institute Tech. Rep. No.84-175, 54 p.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis.
1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State, p. 209–243. *In* P. S. Hammond, S. A. Mizroch, and G. P. Donovan (eds.), Individual recognition of cetaceans: use of photo-identification and other techniques to estimate population parameters. Rep. Int. Whal. Comm., Special Issue 12.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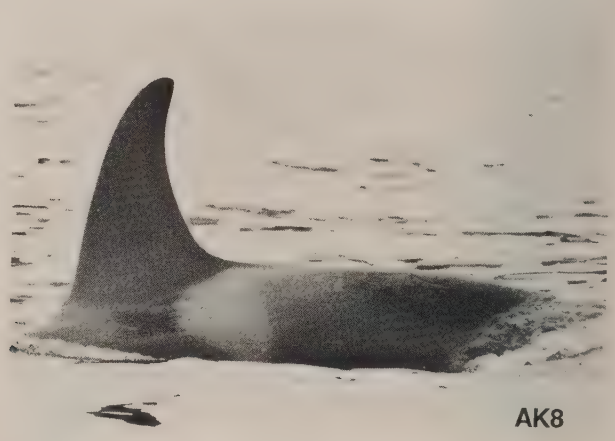
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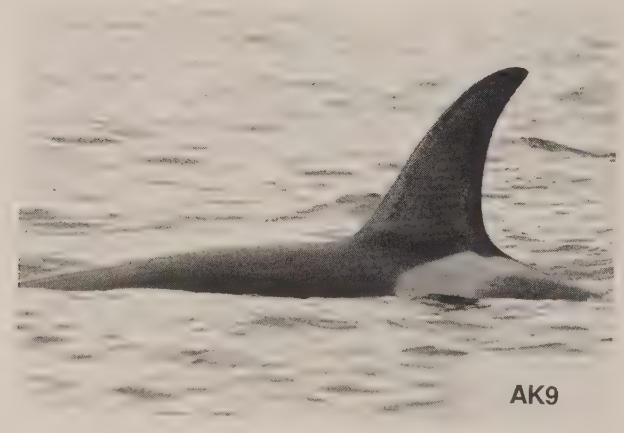
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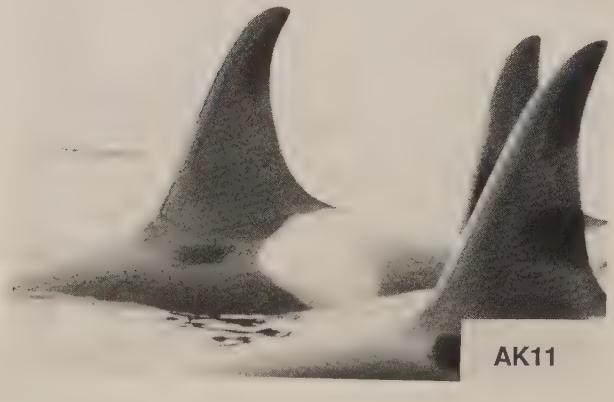
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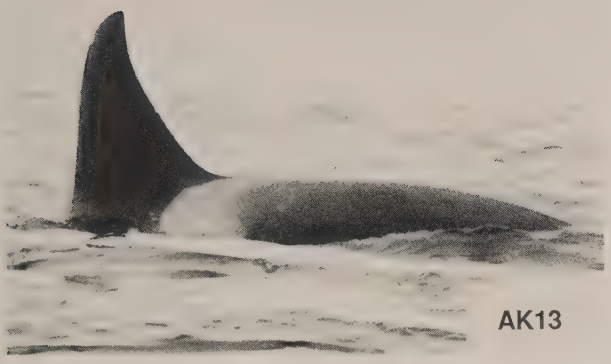

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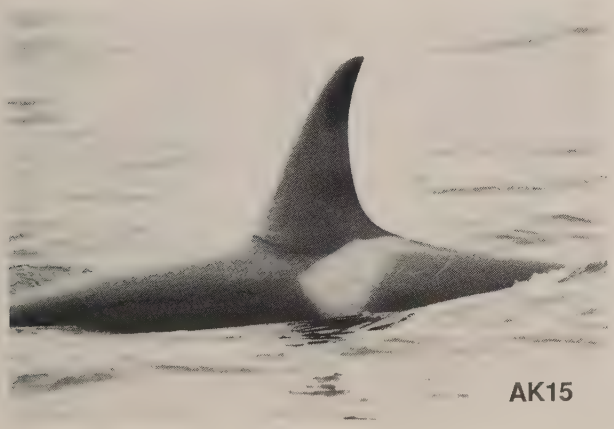

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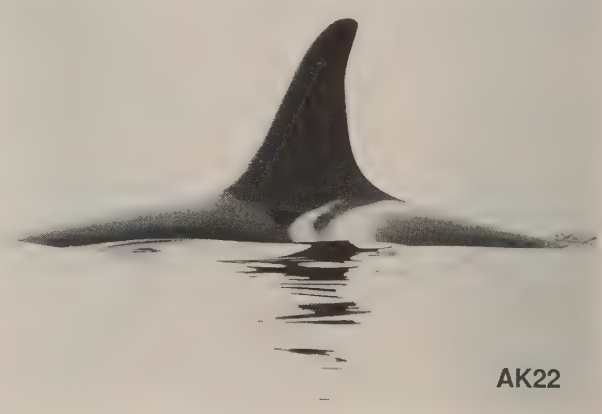

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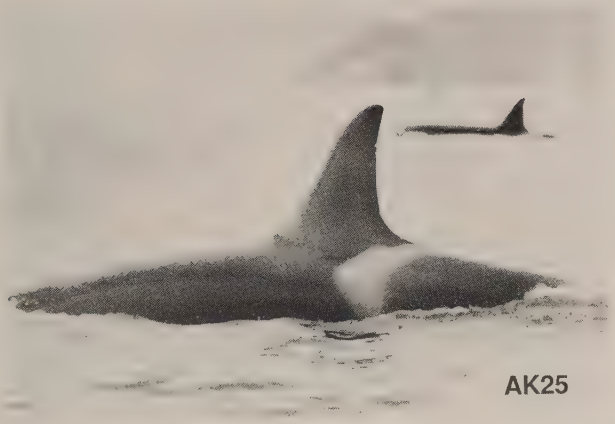

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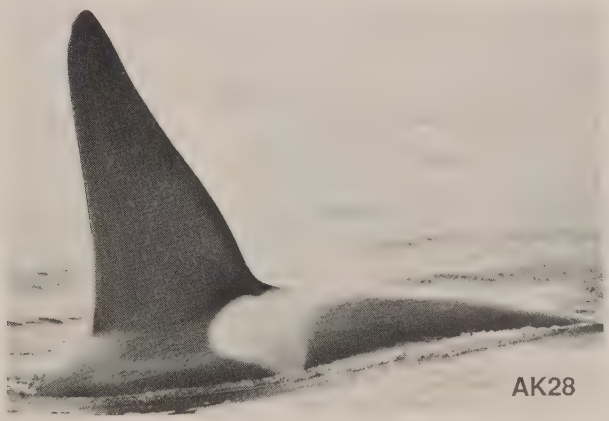

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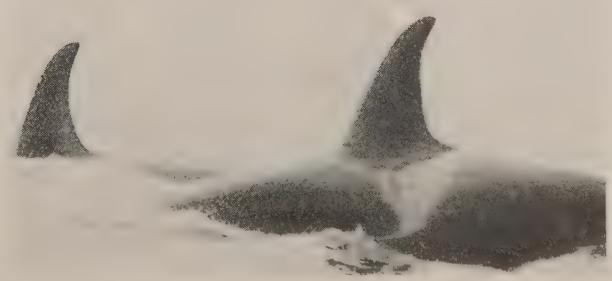

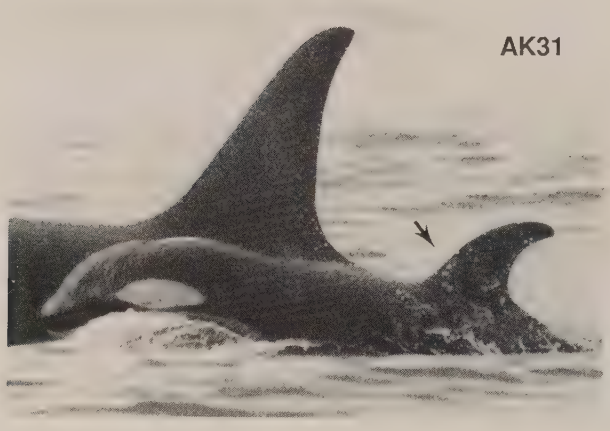
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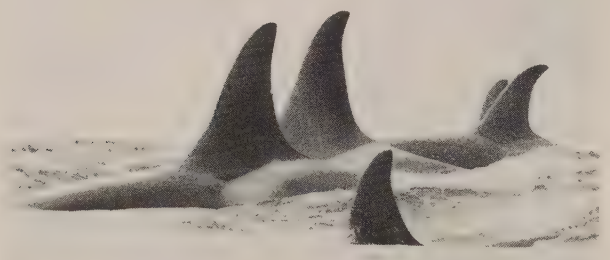
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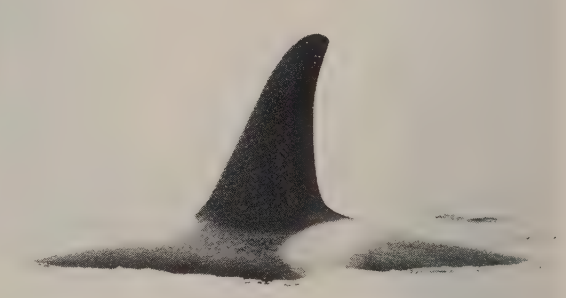
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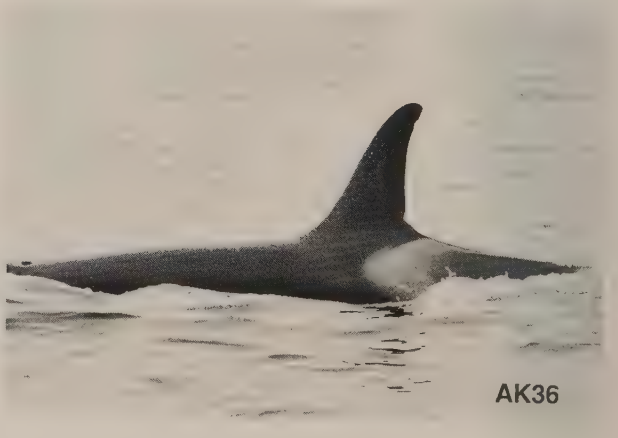
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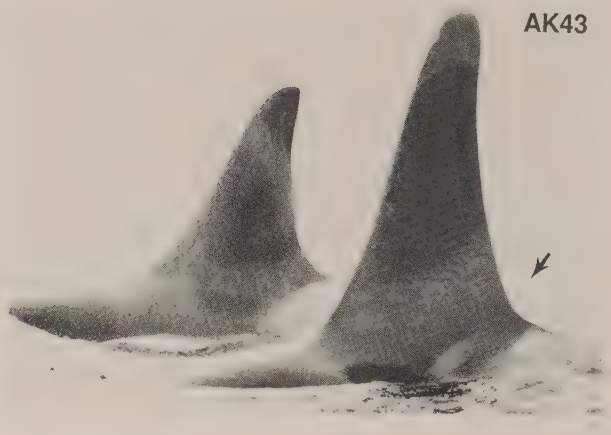
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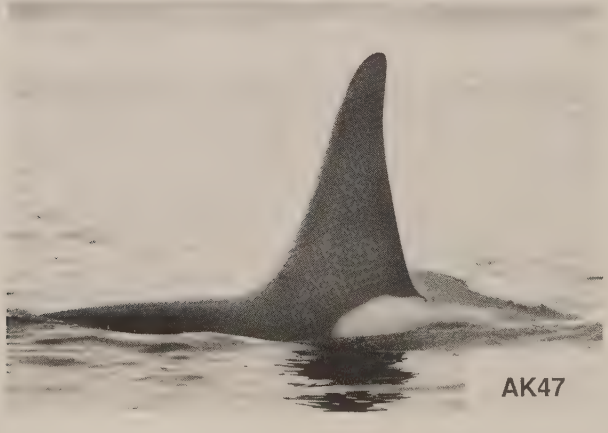
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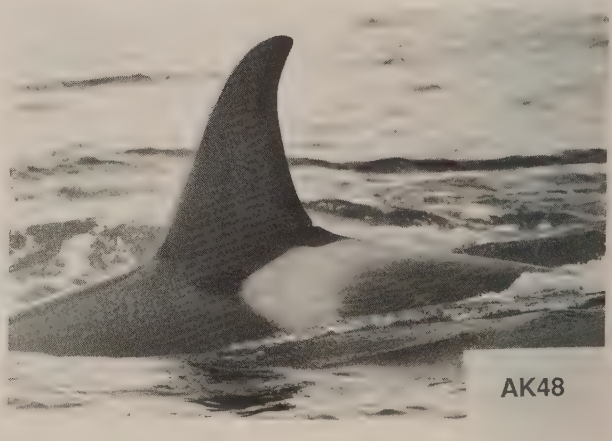
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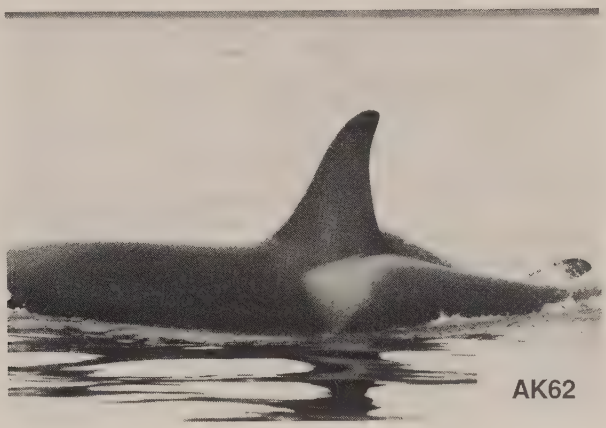

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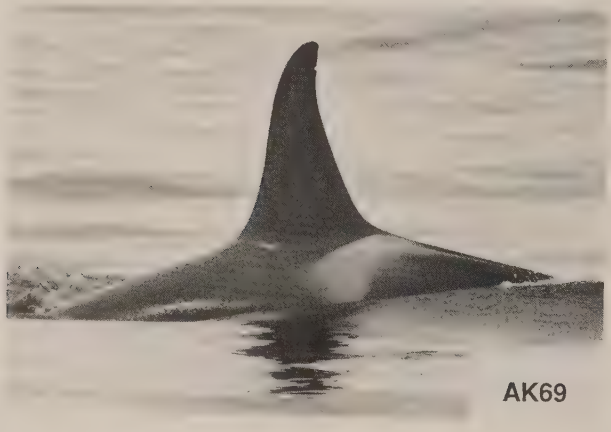
AK68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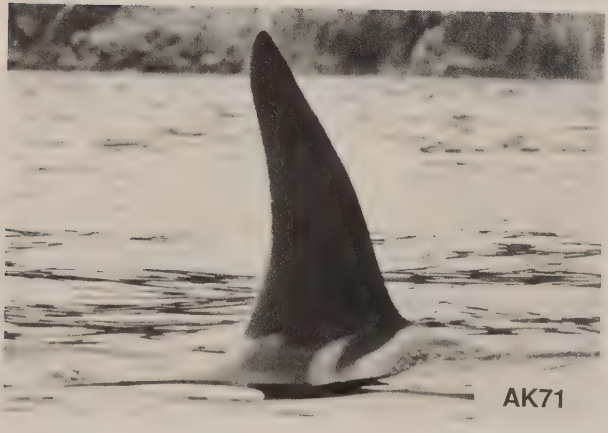
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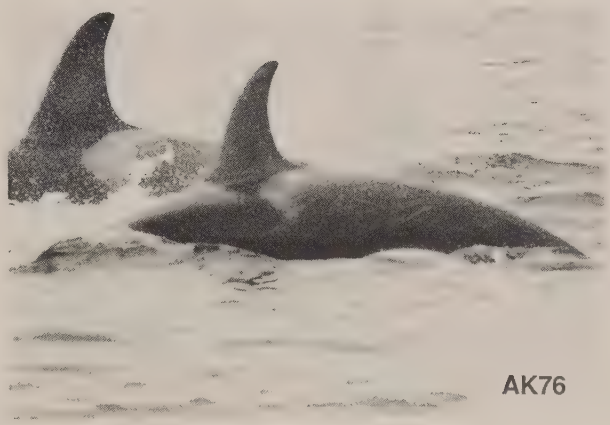
AK75



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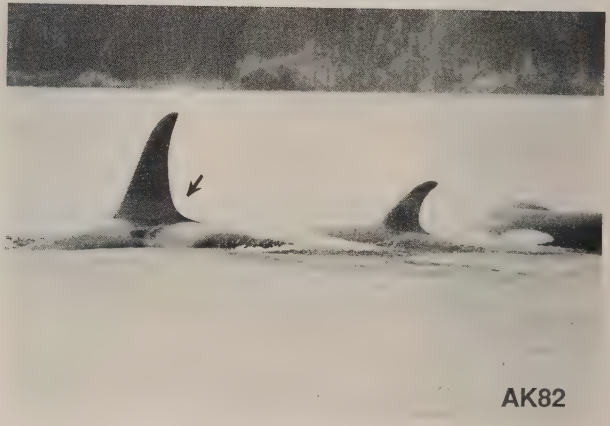

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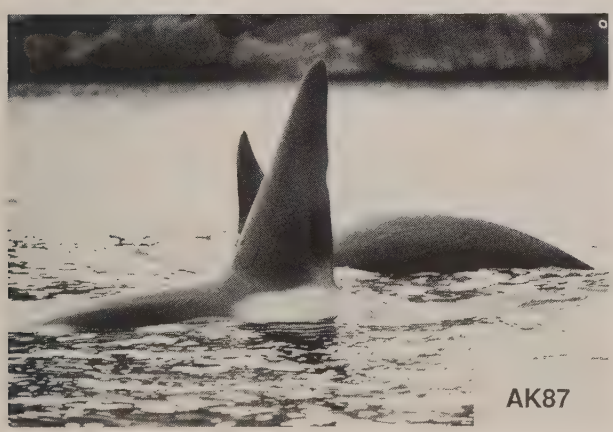

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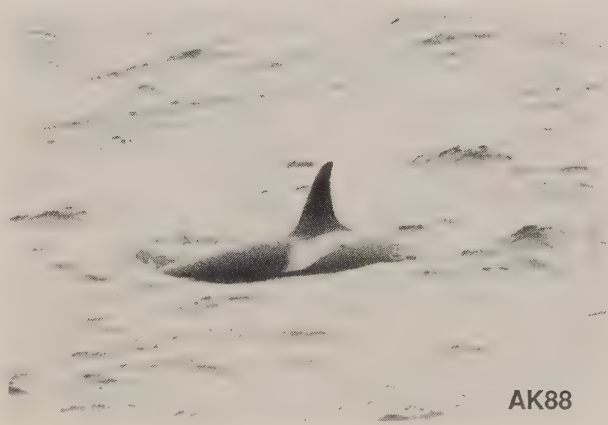

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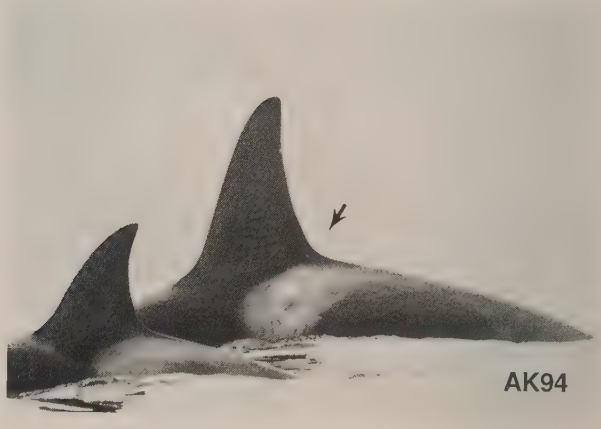
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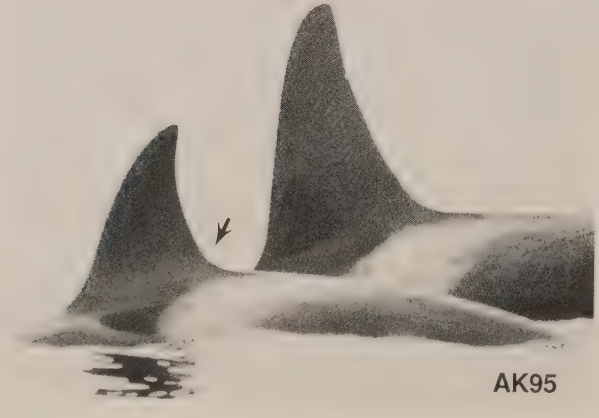
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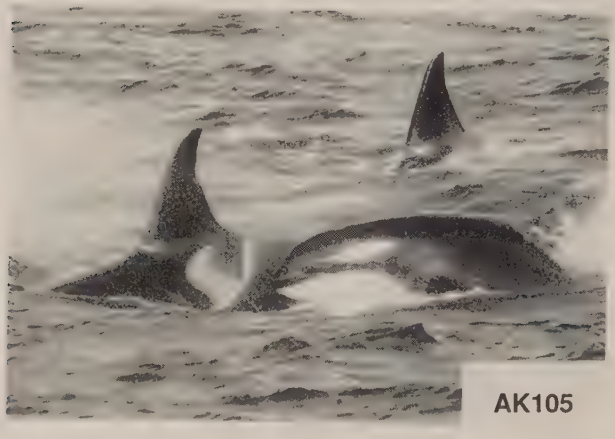
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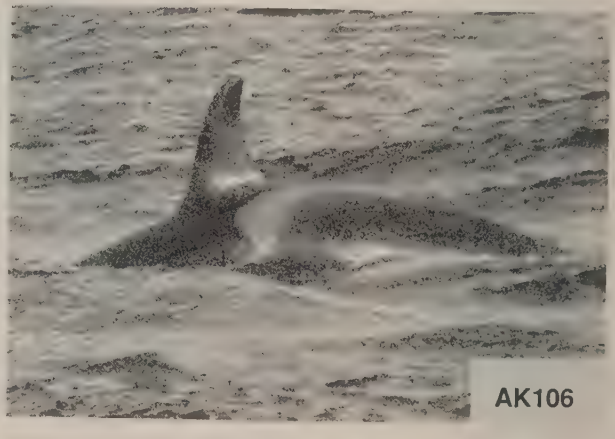
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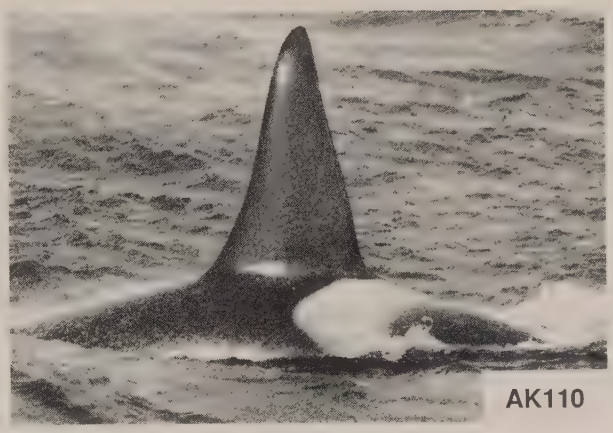
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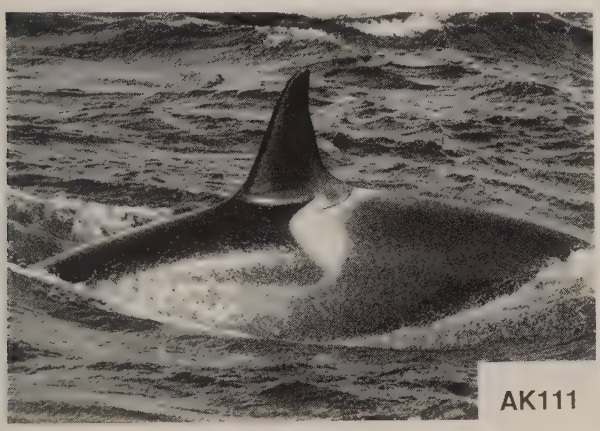
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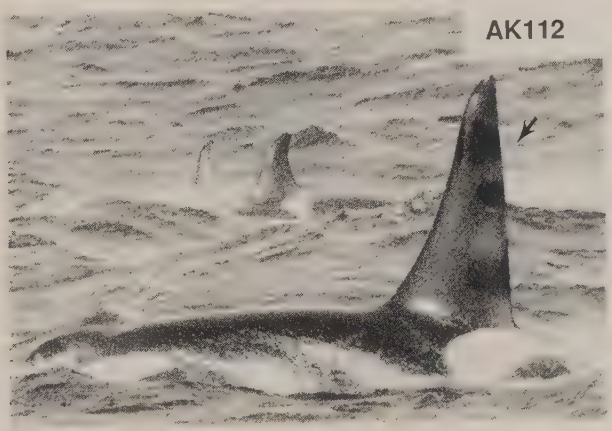
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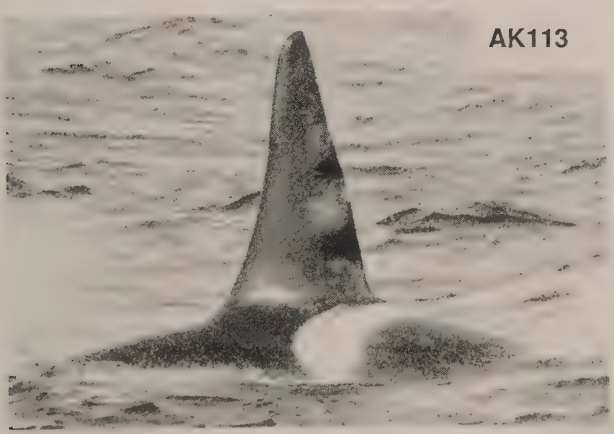
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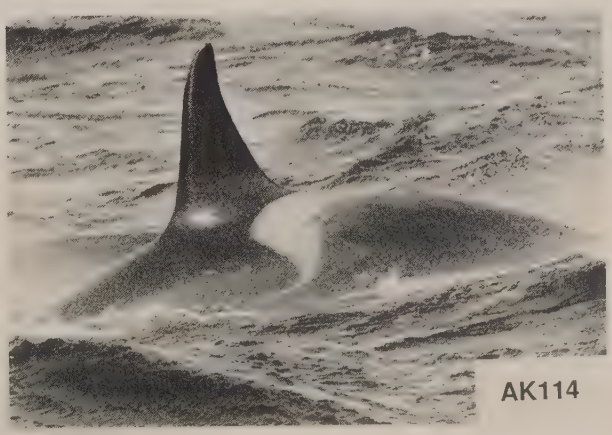
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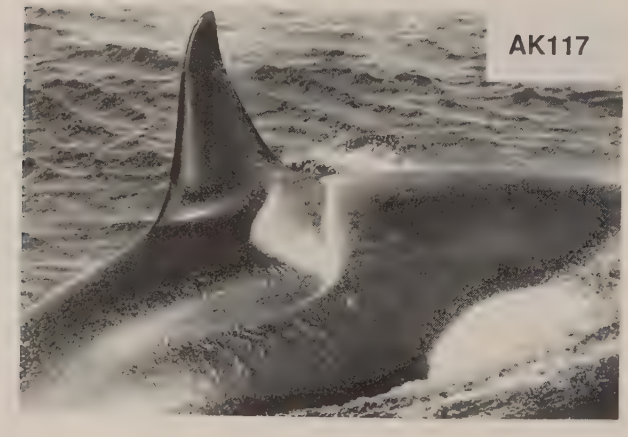
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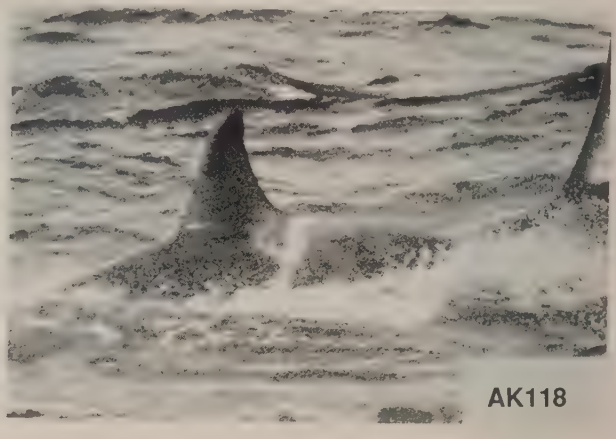
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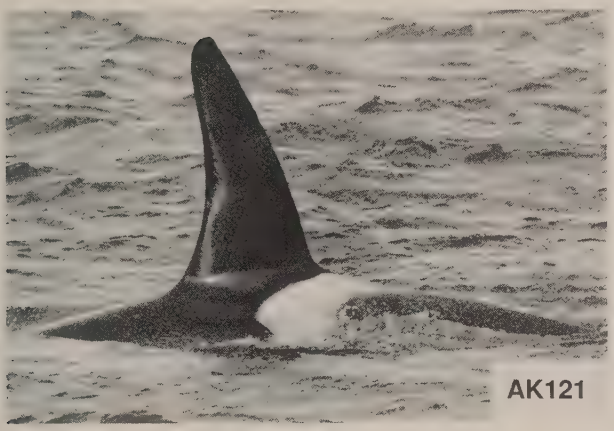
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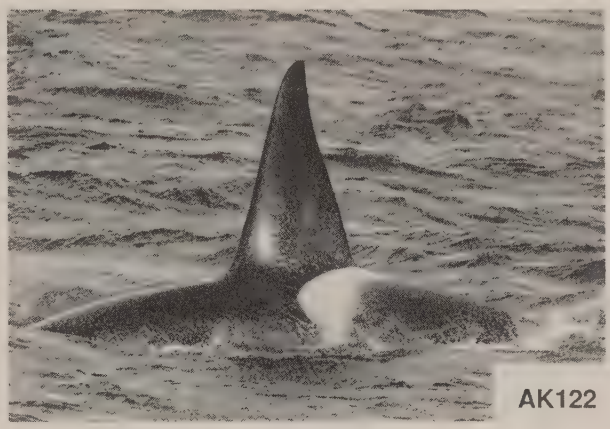
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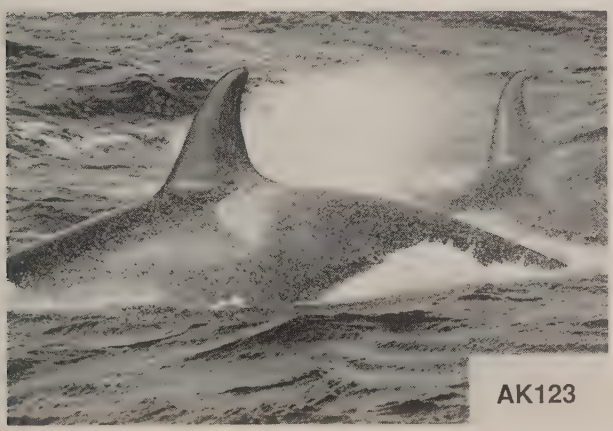
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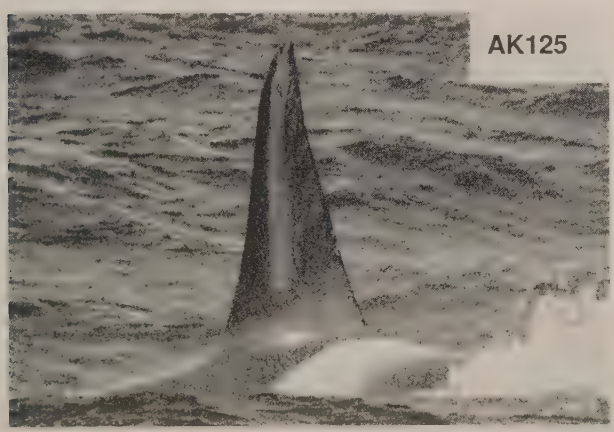
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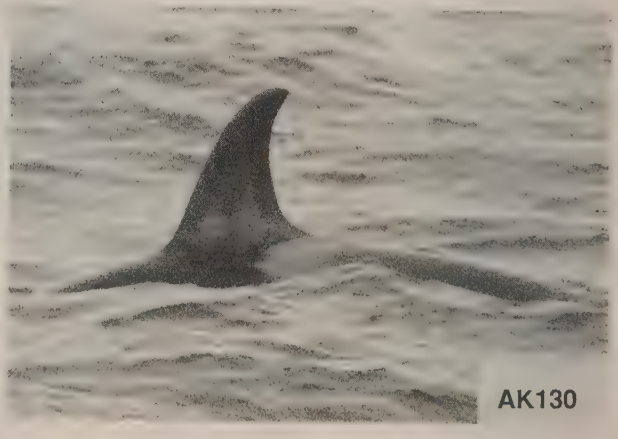

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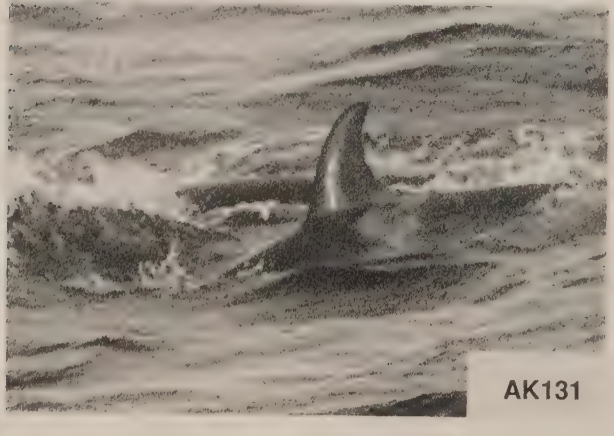

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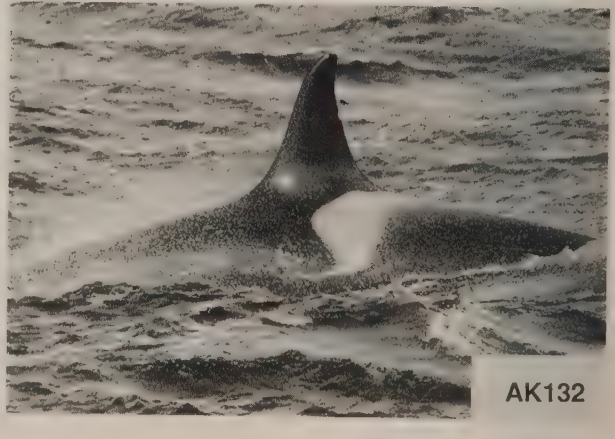

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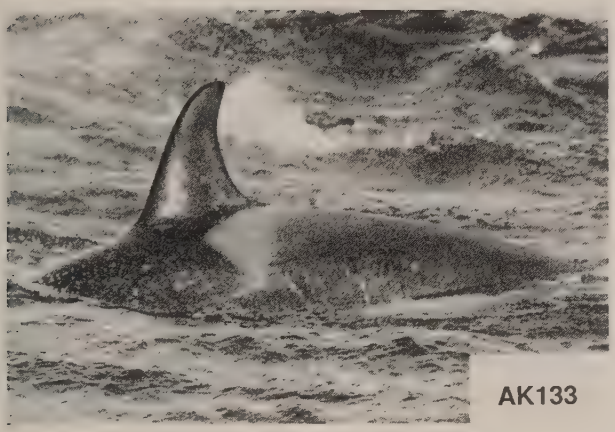
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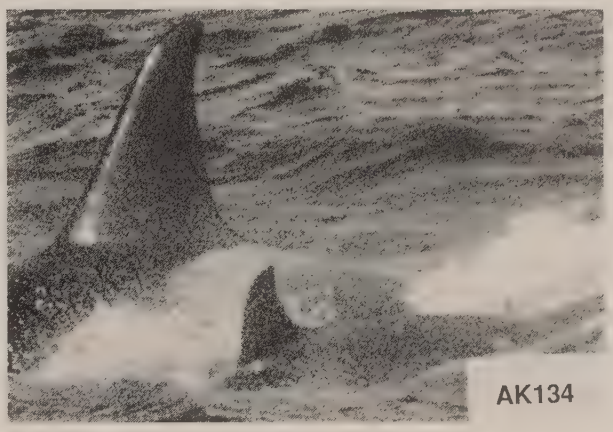
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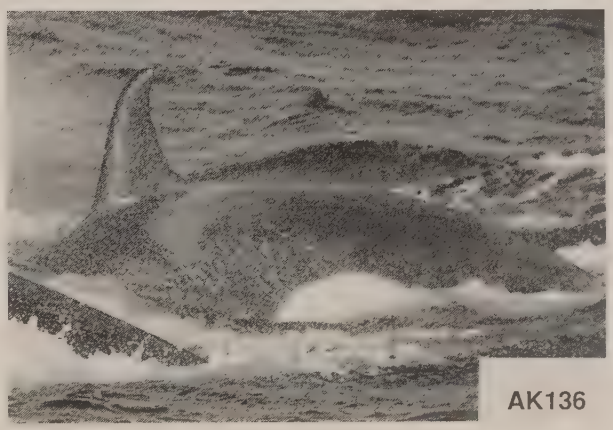
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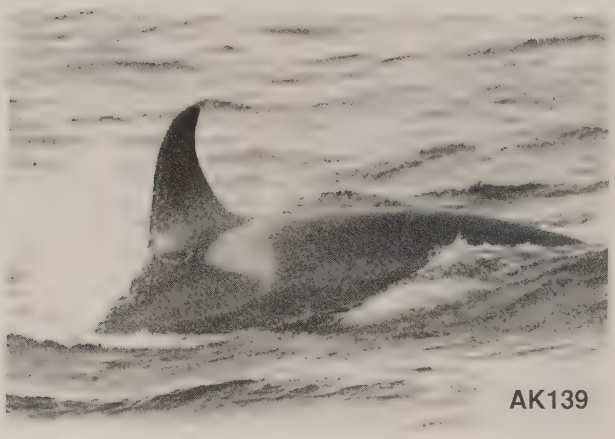
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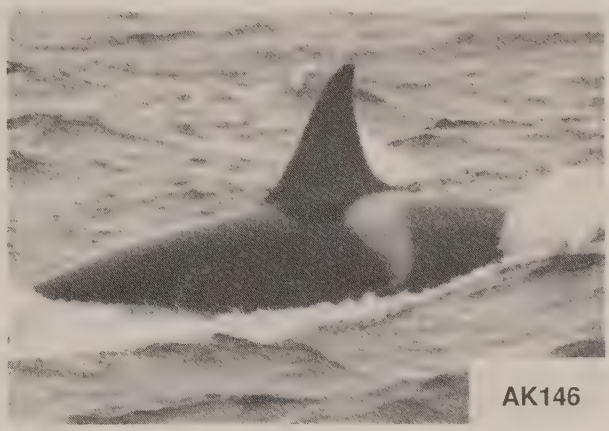
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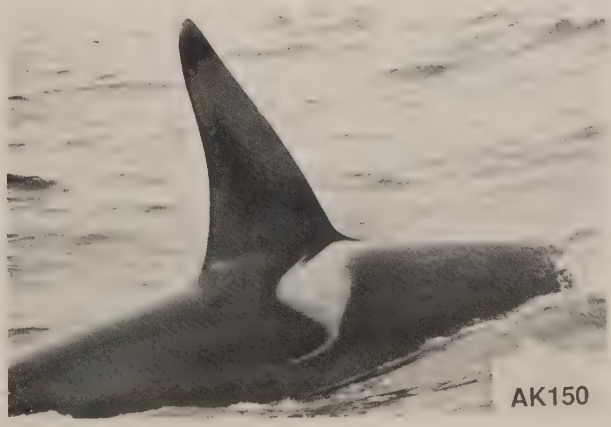
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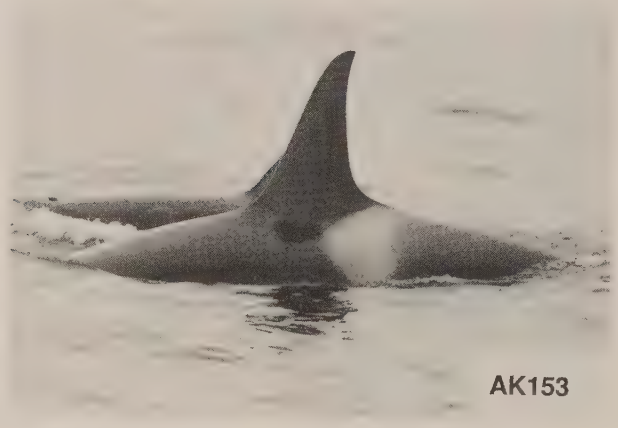
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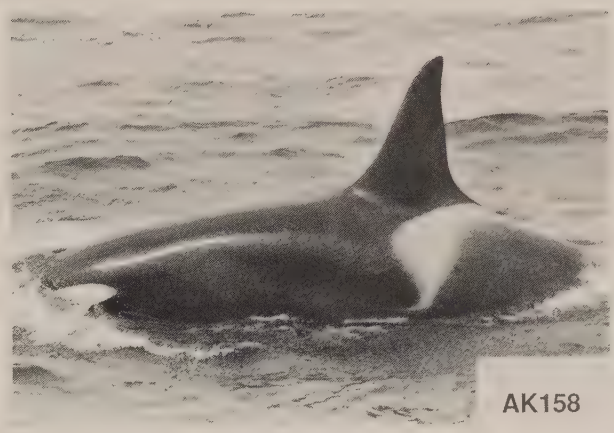
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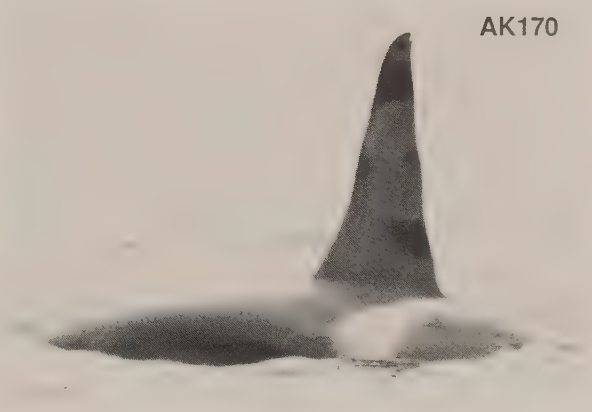

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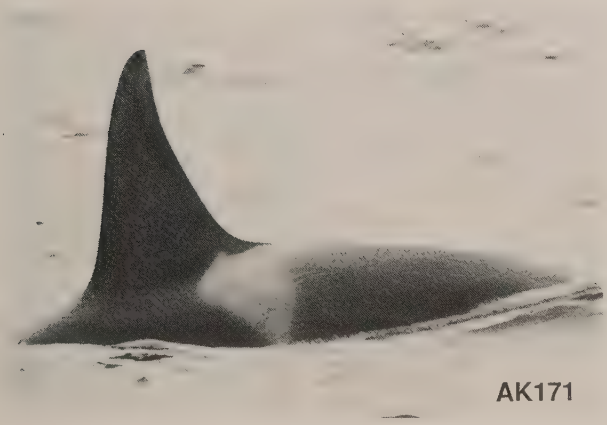
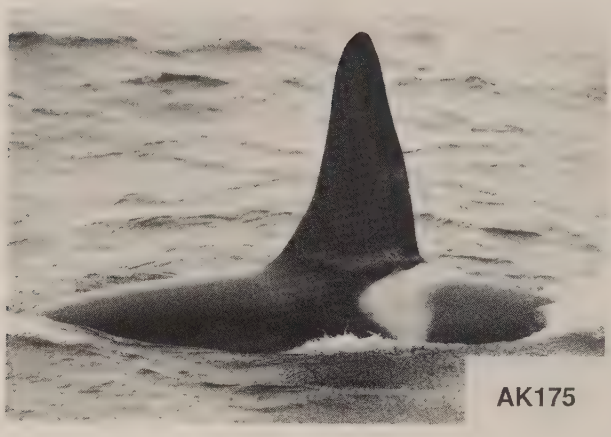


AK171

AK172

An internal match was found.
AK173 equals AK207.

AK174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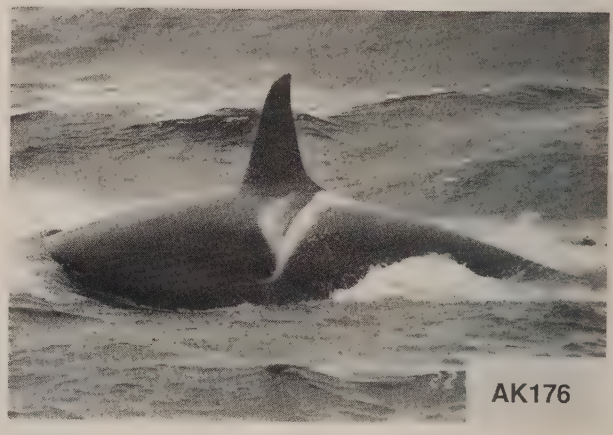
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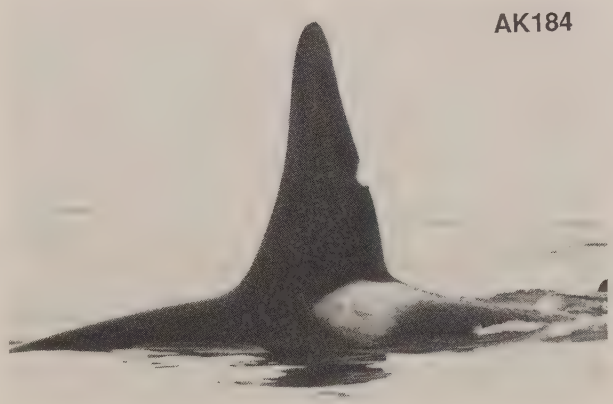
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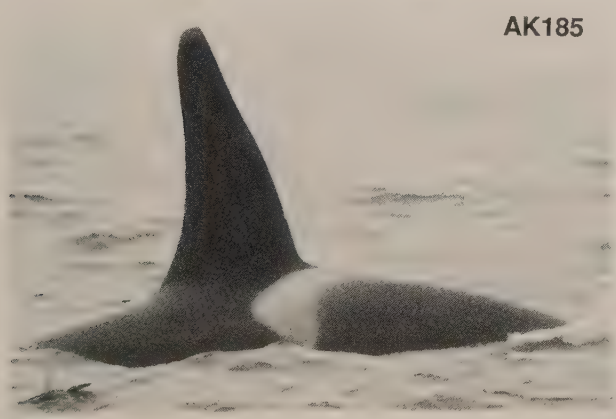
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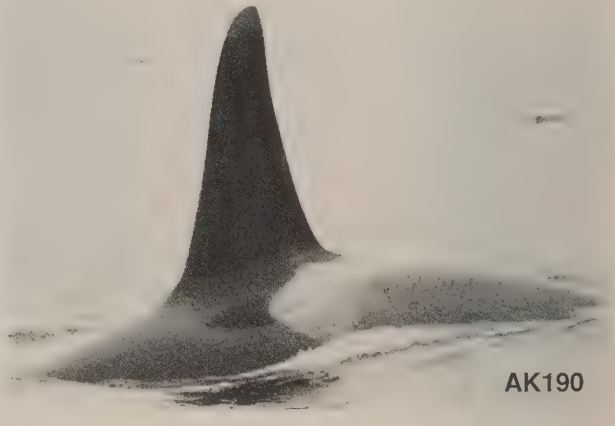
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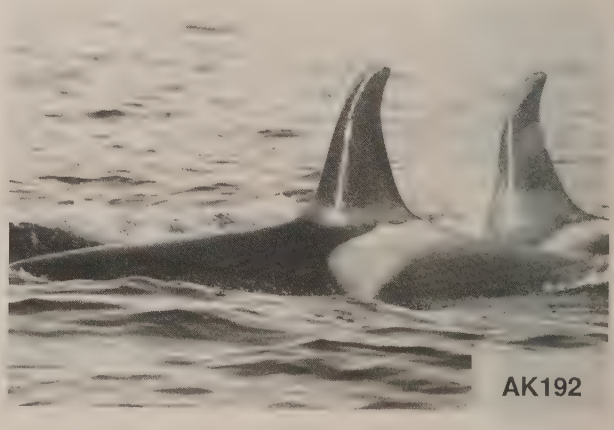
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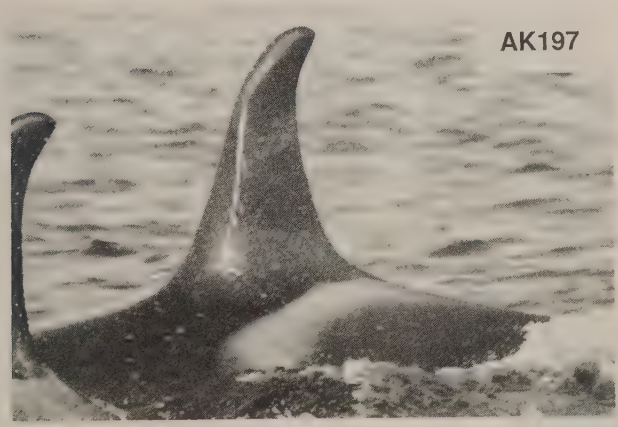

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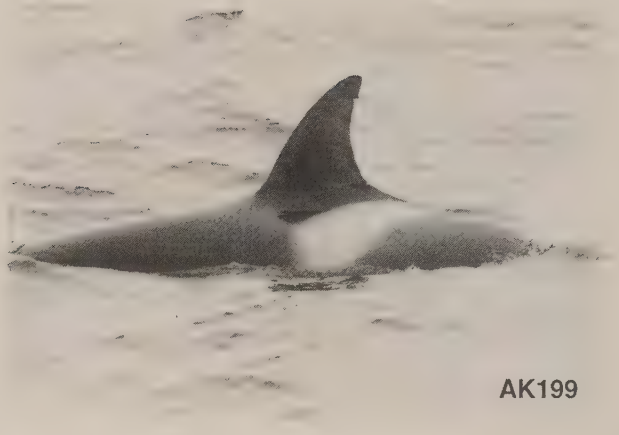
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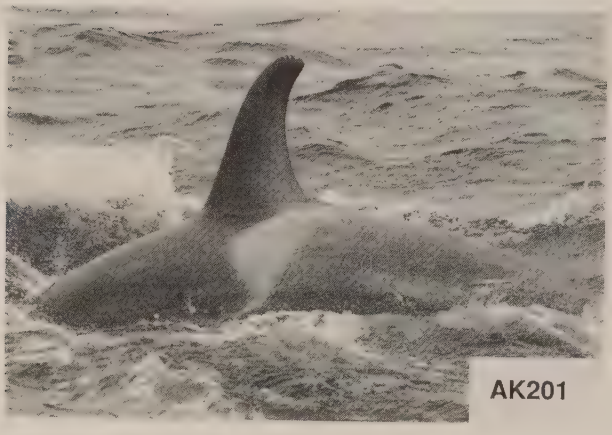
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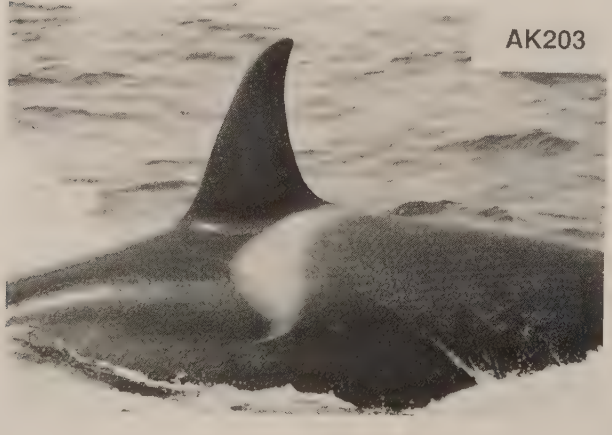
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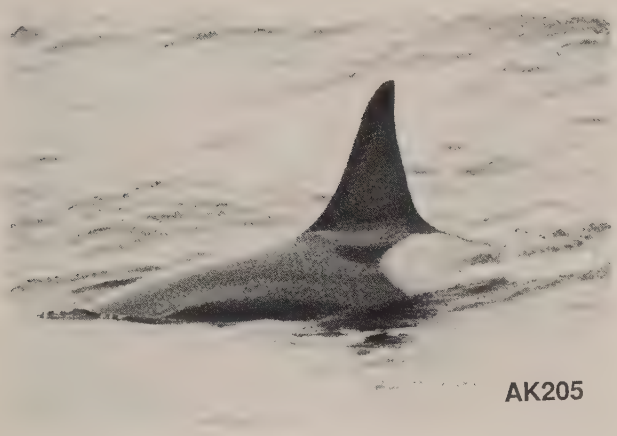
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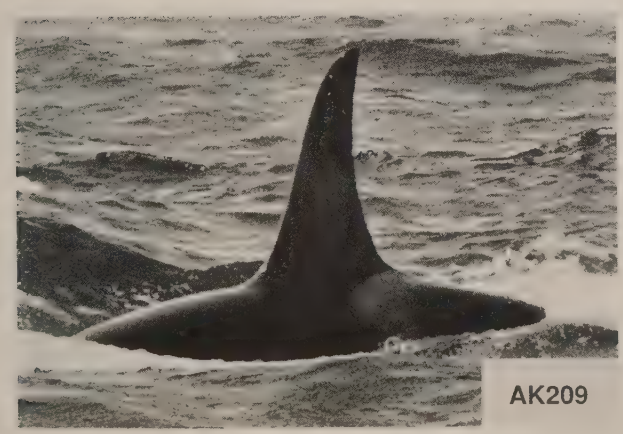
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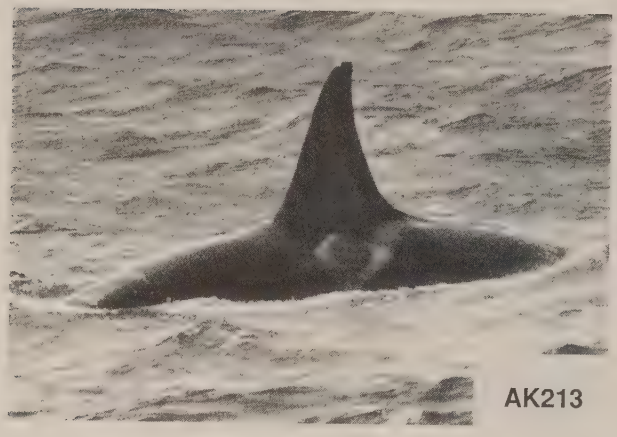
AK210 AK211 AK212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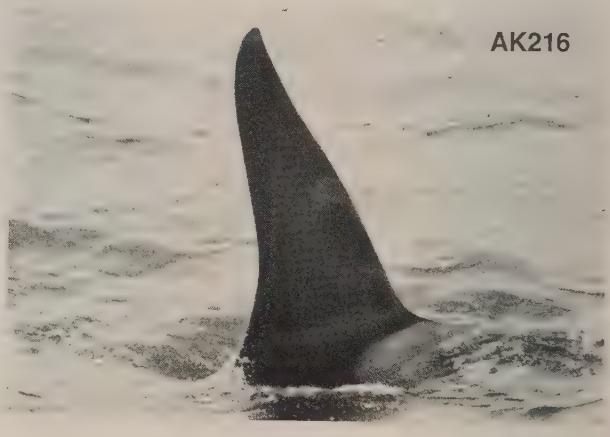
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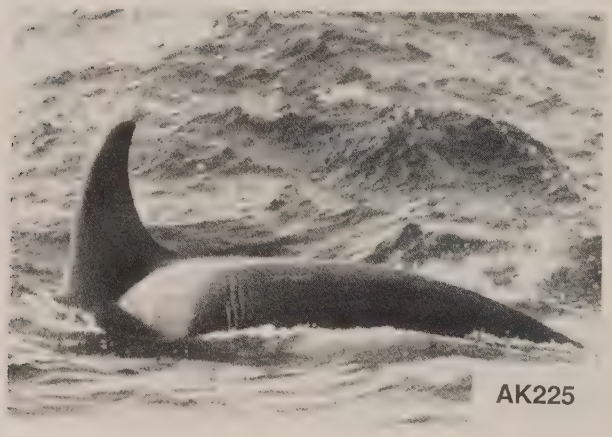

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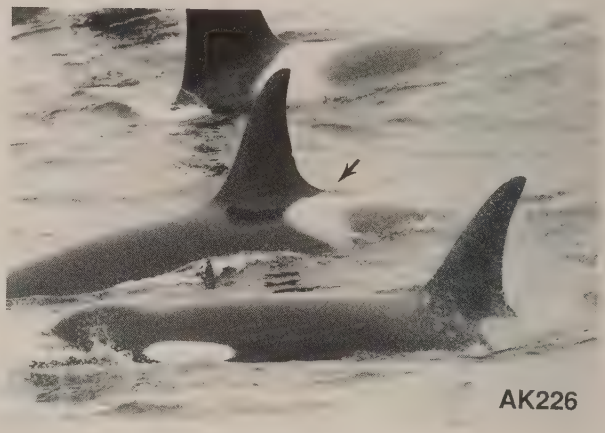

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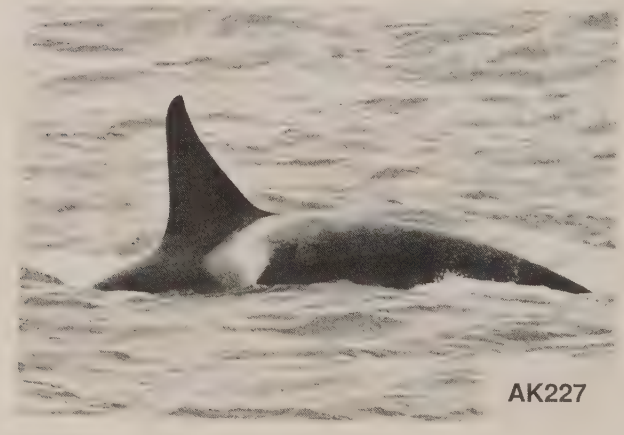

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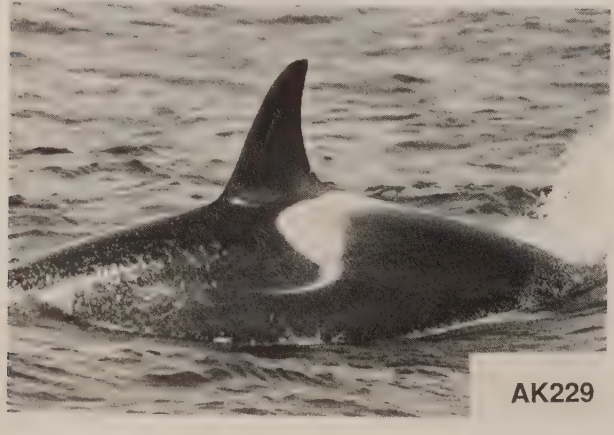

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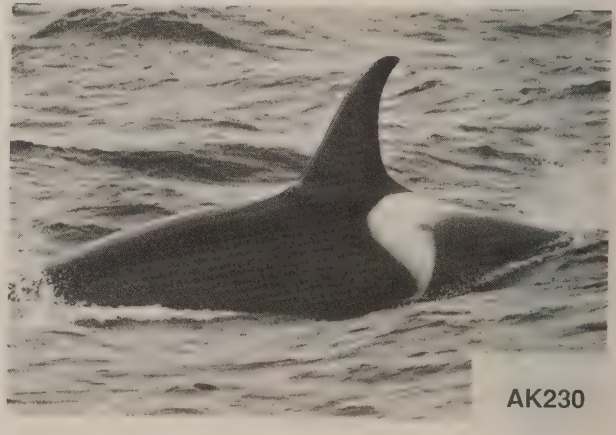

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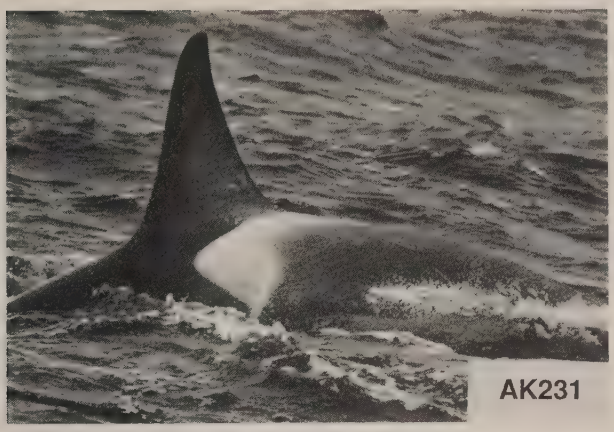
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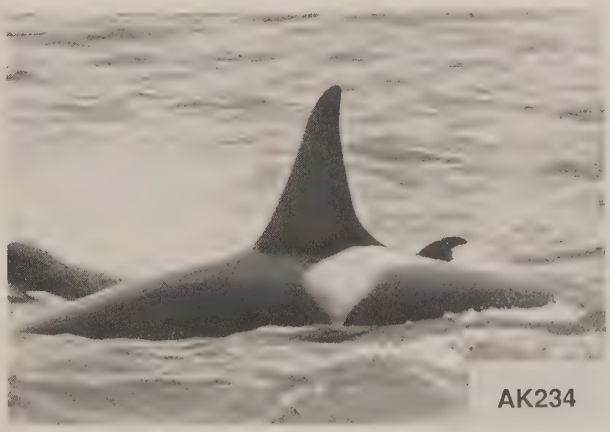
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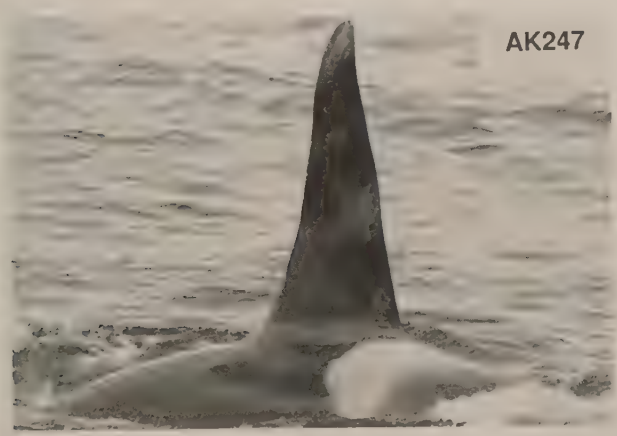
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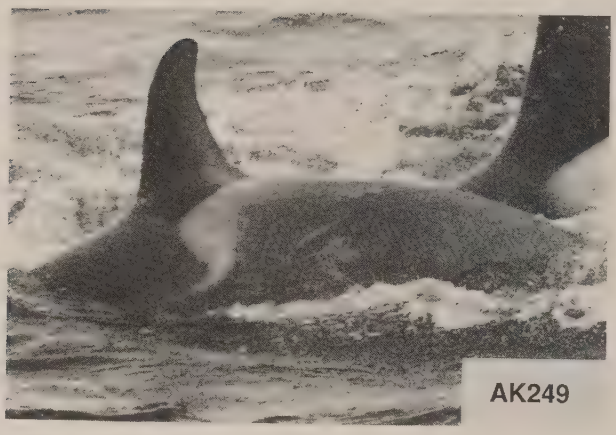
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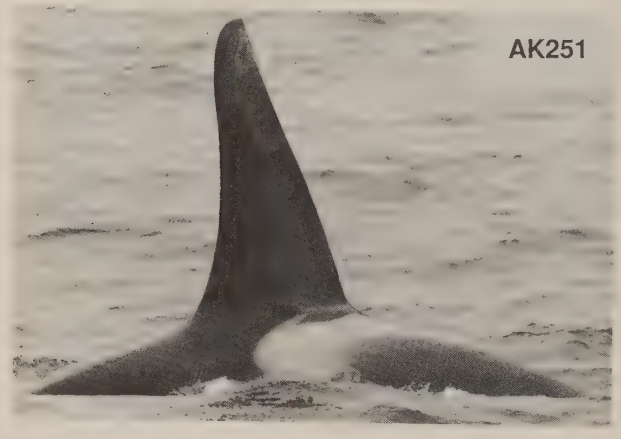
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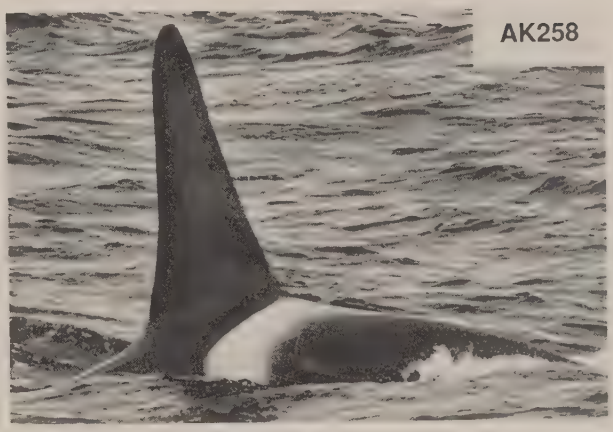
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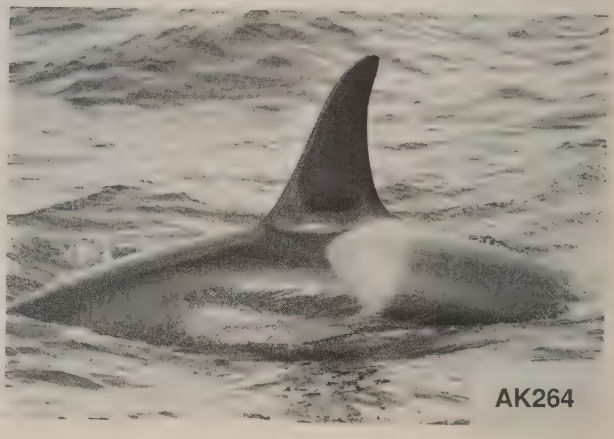
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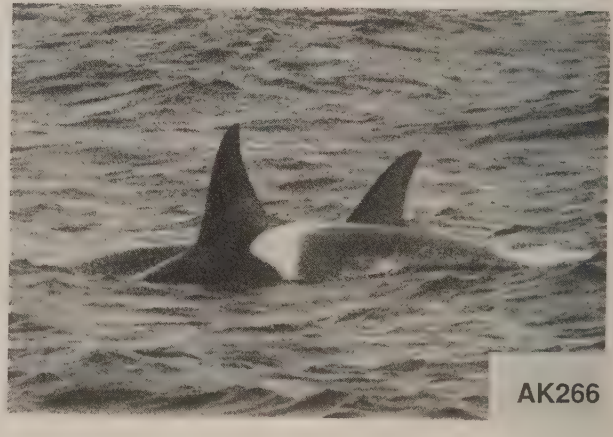
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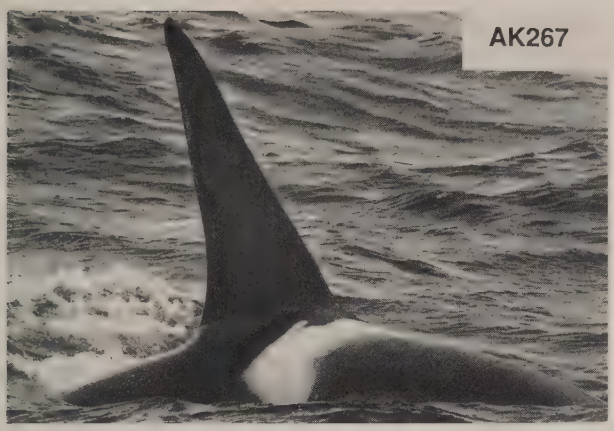
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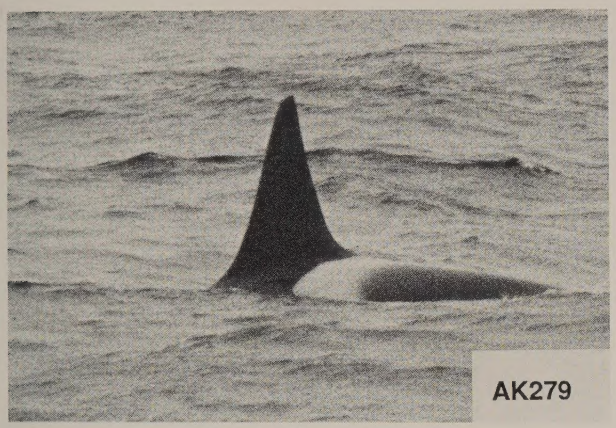
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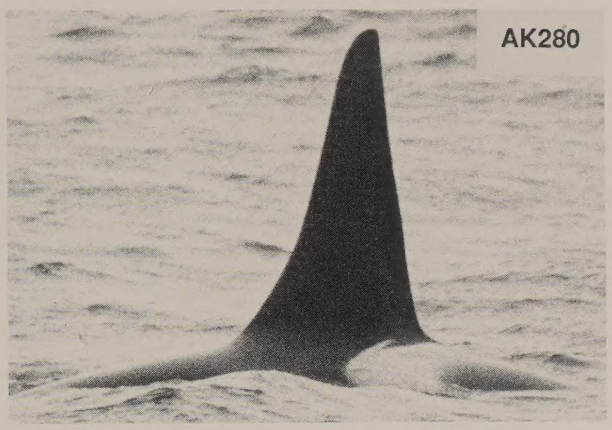
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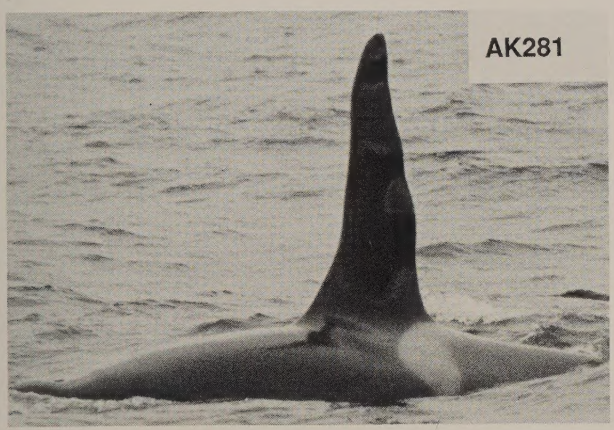
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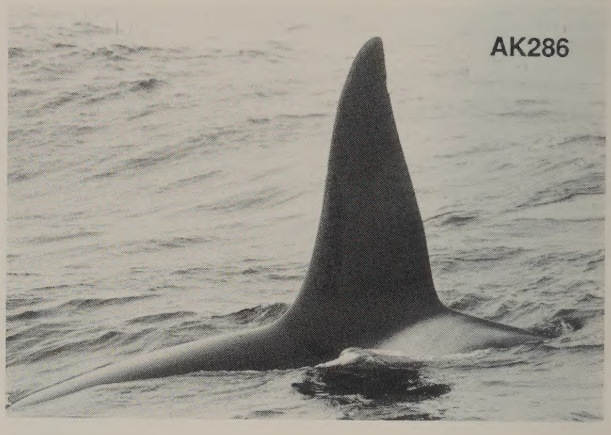
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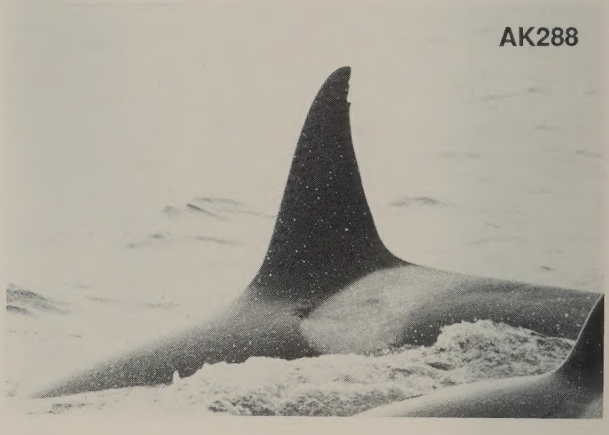
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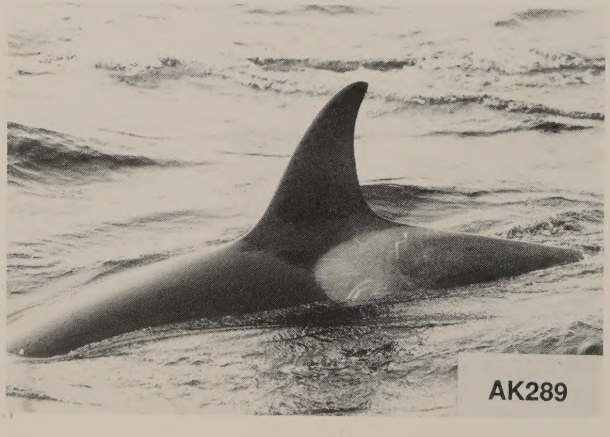
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